**DS3GPP TSG-RAN WG2 Meeting #116-e R2-210xxxx**

**Online, November 1-12, 2021**

**Agenda Item: 6.1.4.3**

**Source: Huawei, HiSilicon**

**Title: Summary of [AT116-e][013][NR16] UE capabilities II**

**Document for: Discussion and decision**

# Introduction

This document summarizes the following offline discussion.

* [AT116-e][013][NR16] UE capabilities II (Huawei)

Scope: Determine agreeable parts in a first phase, for agreeable parts agree on CRs. Treat [R2-2111058](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2111058.zip), [R2-2110777](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110777.zip), [R2-2110483](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110483.zip), [R2-2110484](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110484.zip), [R2-2110780](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110780.zip), [R2-2110627](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110627.zip), [R2-2110628](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110628.zip), [R2-2110629](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110629.zip), [R2-2110973](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110973.zip),

Intended outcome: Report, Agreed CRs if applicable

Deadline: Schedule 1

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# Discussion

## Part 1: Intended to determine agreeable parts

### UL TX Switching (MIMO layer reporting)

[R2-2111058](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2111058.zip) Clarification on UL MIMO layer reporting for 1Tx-2Tx switching Huawei, HiSilicon, China Telecom, Apple CR Rel-16 38.306 16.6.0 0661 - F NR\_RF\_FR1-Core\

[R2-2110777](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110777.zip) Support of UL Tx switching and relation with further enhancements Ericsson discussion

In RAN2#115-e meeting, the following two interpretations about Rel-16 UE capability reporting of UL Tx switching have been discussed. After the discussion during the meeting and post-meeting email discussion, companies agreed to go for interpretation 2, thus Interpretation 2 was adopted in Rel-17 running CR. For Rel-16 spec change, since it was not the scope of Rel-17 discussion, no corresponding CR was agreed and rapporteur suggested companies to bring CRs in later meeting for discussion.

**Interpretation 1**: The UE can signal 2layer-2layer in a feature set row of the band pair. And either band can be used as carrier 2 in 1Tx-2Tx switching.

**Interpretation 2**: The UE should signal only 1layer-2layer in feature set for the band pair to indicate the capability of 1Tx-2Tx. Carrier2 can only be the band with 2layer MIMO. This interpretation means that the UE has to signal two feature set rows for a given band pair if it wants to indicate the 1Tx-2Tx switching can be bi-directional.

**Q1 Which interpretation above do companies support for Rel-16?**

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| --- | --- | --- |
| **Company** | **Interpretation 1 or 2?** | **Comments** |
| Ericsson |  | While we think interpretation 1 is cleaner, we can accept interpretation 2 if we can clarify that a UE indicating support of Rel-17 2Tx-2Tx should also support Rel-17 2Tx-1Tx case. |
| Qualcomm Incorporated | 2 | We would stick to the current RAN2 agreement.  We are fine to further clarify that the UE supporting 2T-2T shall also support 2Tx-1Tx. But it looks clear from the mandatory inclusion of *uplinkTxSwitchingPeriod-r16*. |
| OPPO (Qianxi) | See comment | No strong view, yet we understand last meeting R2 leans towards interpretation-2 in order to ensure backwards compatibility, so wonder if interpretation-1 is now pursued, whether any compatibility issue (even though it is more aligned with the fallback concept).  Or, whether one can consider to adopt interpretation-1 since R17 (to save the signaling due to 1layer-2layer reporting)? |
| Huawei, HiSilicon | 2 | We also prefer to stick to interpretation 2.  Our concern on interpretation 1 is there are some restrictions on both of UE and network, e.g.  1. if UE reporting 2layer+2layer for 2T-2T switching, the UE is required to support bi-direction 1T-2T switching for the given band pair.  2. if UE is allowed to reporting 2layer+2layer for bi-direction 1T-2T switching, it needs to make sure this capability can apply to 2T-2T switching. Meanwhile network must be able to comprehend such case.  For the clarification to Interpretation 2 mentioned by Ericsson, we agree with Qualcomm that for a given band pair, if UE want to indicate Rel-17 period for 2T-2T switching, it must include Rel-16 band index and Rel-16 period which means it must support 1T-2T switching on the band pair. |
| Nokia |  | We agree that it would be good to allow the fallback of 2Tx-2Tx case to 2Tx-1Tx or 1Tx-2Tx which maintains an earlier agreed principle. In that sense we can accept Interpretation 2 if given along with the fallback. |
| China Telecom | 2 | We also prefer Interpretation 2, which is also the majority view in the discussion of last meeting. And we also support to make clarifications in R16 spec. |
| MediaTek | 2 | We prefer to keep interpretation 2 as discussed in previous meeting. We are open on how to clarify the fallback aspect in Rel-17. |
| vivo | 2 | There’s no interpretation ambiguity for supporting legacy 1Tx-2Tx with int.2. As for R17, one way to deal with it is that UE indicating support of 2Tx-2Tx can be interpretated as supporting 2Tx-1Tx as well, since it was agreed that fallback capability from 2 CCs to 1 CC can be supported. |
| Samsung | 2 | From RAN4 input, UE supporting 2TX-2TX switching also supports 1TX-2TX or 2TX-1TX switching (i.e. fallback).  Thus, if the interpretation 2 is applied even to R16, there would be contradictory between R16 capability derived from R17 (i.e. 2TX-2TX) and the R16 capability from the interpretation 2.  On the other hand, we would like to keep a consistency for R16 and R17. We can apply the interpretation 2 even to R16, but in order to avoid any confusion, we may introduce a restriction for capability signalling. |
| Apple | 2 | Regarding the concern from Ericsson on how to interpret the fallback from Rel-17 2Tx-2Tx to Rel-16 1Tx-2Tx, actually the Rel-17 UL Tx switching cases already cover the Rel-16 1Tx-2Tx, thus we think if UE supports Rel-17 UL Tx switching, Rel-16 1Tx-2Tx are naturally supported as a subset. |
| Intel | 2 | We also prefer to stick to the current RAN2 agreement. We can further discuss if the fallback aspect needs to be clarified. |
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### UL TX Switching (UL MIMO Coherence)

[R2-2110483](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110483.zip) Adding UE capability of UL MIMO coherence for UL Tx switching Huawei, HiSilicon, China Telecom, Apple CR Rel-16 38.306 16.6.0 0635 - F NR\_RF\_FR1-Core R2-2108618

[R2-2110484](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110484.zip) Adding UE capability of UL MIMO coherence for UL Tx switching Huawei, HiSilicon, China Telecom, Apple CR Rel-16 38.331 16.6.0 2786 - F NR\_RF\_FR1-Core R2-2108619

[R2-2110780](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110780.zip) UL MIMO coherence for Tx switching between two carriers Ericsson discussion

RAN4 sent LS (R4-2107765) on Rel-16 UL Tx switching:

* Introduce UE capability to indicate support of the uplink codebook subset for the carrier capable of two antenna connectors, when UE is configured with uplink switching with parameter *uplinkTxSwitching-r16* and uplink switching is triggered by the switching mechanisms specified in sub-clause 6.1.6 of TS 38.214 between last transmitted SRS and scheduled PUSCH transmission.
* UE capability is defined as per band combination when also for band combinations with a carrier capable of one-port transmission + a carrier capable of two-port transmission are indicated with capability *ULTxSwitchingBandPair-r16*. For band combinations with 2Tx to 2Tx switching, RAN4 will further discuss on how to handle the above new capability in Rel-17.
* If the above capability is absent, the existing per band UE capability *pusch-TransCoherence* is applicable to the scenario when UE is configured with uplink switching with parameter *uplinkTxSwitching-r16* and uplink switching is triggered by the switching mechanisms specified in sub-clause 6.1.6 of TS 38.214 between last transmitted SRS and scheduled transmission.
* If UE indicates the above capability as *nonCoherent* and the existing per band UE capability *pusch-TransCoherence* as *fullCoherent* or *partialCoherent*, when UE is configured with uplink switching with parameter *uplinkTxSwitching-r16* and uplink switching is triggered by the switching mechanisms specified in sub-clause 6.1.6 of TS 38.214 between last transmitted SRS and scheduled PUSCH transmission, UE is not expected to receive TPMI for coherent codebook subset.

Two ways are given:

**Option 1** (from Huawei): Adding Rel-16 parameter *uplinkTxSwitching-PUSCH-TransCoherence* to indicate the UE capability of UL MIMO coherence for UL Tx switching. Following RAN4 LS, if the above capability is absent, the existing per band UE capability *pusch-TransCoherence* is applicable.

**Option 2** (from Ericsson): The UE indicates support of *pusch-TransCoherence* for UL Tx switching solely based on the *pusch-TransCoherence* field the UE reports for the UL Tx switching BC branch. Inform RAN4 on RAN2 design choice on *pusch-TransCoherence* for UL Tx switching.

**Q2 Which option above do companies support?**

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| **Company** | **Option 1 or 2?** | **Comments** |
| Ericsson | Option 2 | We think this could avoid inter-operability problems in the future and is in line with the RAN2 guidelines on UE capabilities that was sent to RAN1 and RAN4. |
| Qualcomm Incorporated | Wait for RAN1 | The discussion of the handling of the MIMO coherence capability for non-UL-switching CA, which in turn affects the handling of UL-switching case, is pending from the last RAN plenary meeting where majority of companies preferred to continue the discussion in RAN1. RAN1 agenda of the last meeting however did not cover this topic unfortunately.  **RP-212108** **UL MIMO coherence capabilities** ***Qualcomm Incorporated***  handled in email discussion [93e-29-UECapability]    Observation: Some confusion as to the relation with the referenced RAN4 LS. Most companies prefer that this is discussed at WG level.  conclusion: No conclusion at RAN#93e. Expect that this can be discussed at WG level (based on company contributions there).  (The conclusion mentions discussion at WG level, but the nature of the discussion is very much RAN1 domain. But if companies prefer, we are also fine to discuss the same technical content in RAN2)  Our view is the existing “per band” MIMO coherence capability is misplaced given how a given oscillator signal is used for the different Tx chains is largely dependent on band combination. Adding something on top of the existing, somewhat broken, UL MIMO coherence capability is not beneficial for UL TX switching. |
| OPPO (Qianxi) | See comment | W.r.t the gap between option-1/2: we tend to agree with the point by option-2 that “RAN2 previously indicated to RAN1/4 (R2-2002378) that absence of a field should not imply support of a feature”, yet wonder if can be solved by simply adding a codepoint in the *pusch-TransCoherence* field (we understand option-2 assume it is a per-BC flag) in case the per-band report is replied on, e.g., “perBand”, instead of relying on the absence of the field.  Yet more than the issue above, more importantly, should we further consider on a finer granularity, e.g., at least per-BC-per-band-pair considering R2 signaling framework is to indicate switching capability per-band-pair within a BC entry? And even a further step is that, we understand R4 is further discussing the capability for 2UL+2UL case for R17, which may lead to an even finer granularity of per-BC-per-band-pair-per-band, should we design the R16 capability with sufficient forwards compatibility to R17+ Tx switching? |
| Huawei, HiSilicon | Option 1 | We noticed the discussion on Rel-15 UL MIMO coherence capability mentioned by Qualcomm. It happened in both RAN1#106 meeting and RP#93 meeting with no conclusion achieved. We are not sure if it would be re-discussed in RAN1 and whether the change on a Rel-15 MIMO capability can be agreed.  As it is a requested capability by RAN4, we prefer RAN2 to capture it following RAN4 agreement. At least RAN2 should not postpone it indefinitely without notifying RAN4.  We do not see any inter-operability issue of option1. The reason RAN4 introduced this capability is some UE implementation cannot guarantee the same coherent capability as normal CA. However, for most of UE there is no issue, then they do not need to be changed to report this new capability if they already implemented Rel-16 UL Tx switching. |
| Nokia | Follow RAN4 | Question to Huawei:  In the [R2-2110483](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110483.zip), there seems to be a reference in as specified in TS 38.101-1 [2]. Shouldn’t this rather be “see clause 6.1.6 and 6.1.1.1 of TS 38.214[12].”  [Huawei] To answer Nokia’s question, this new capability is mentioned in 38101-1 as below. About RAN1 spec, since the UE handles coherent as legacy, only with a different capability, RAN1 spec did not make a change specially, that is why we did not put RAN1 spec as a reference.  When UE is not configured with uplink switching with parameter *uplinkTxSwitching-r16*; or when UE is configured with uplink switching with parameter *uplinkTxSwitching-r16*, and the capability [*uplinkTxSwitching*-*PSUCH-TransCoherence*]is absent or indicated as [‘coherent’]; or when UE is configured with uplink switching with parameter *uplinkTxSwitching-r16*, the capability *[uplinkTxSwitching*-*PSUCH-TransCoherence]* is indicated as [‘non-coherent’],and uplink switching is not triggered by the switching mechanisms specified in sub-clause 6.1.6 of TS 38.214 [10] between last transmitted SRS and scheduled transmission. |
| China Telecom | Option 1 | We agree with HW and Nokia that we shall follow RAN4 LS and discuss how to capture RAN4 agreement in RAN2 spec. For Rel-15 UL MIMO coherence capability issue for non-UL switching raised by Qualcomm, we are also not sure whether there will be discussion or agreement on this issue in RAN1. Therefore, we prefer to follow RAN4 LS. |
| MediaTek | Option 1 |  |
| vivo | Option 1 | Following RAN4 LS would be good unless there’s enough evidence proving the necessity of using solely *pusch-TransCoherence* as opt.2, i.e. the new capability is always the same with the existing per band UE capability *pusch-TransCoherence*. |
| Samsung | Option 1 | Following RAN4 LS (R4-2107765) on Rel-16 UL Tx switching |
| Apple | Option 1 | Regarding the comment from Ericsson on “RAN2 previously indicated to RAN1/4 (R2-2002378) that absence of a field should not imply support of a feature”, we don't see this issue is the same as the previous principle set by RAN2. Here it is merely to say NW can use the other field to determine UE capability if UE does not report. And the existing field *pusch-TransCoherence* would anyway be read by NW even for UL Tx switching operation. |
| Intel | Option 1 | We agree with the other companies to follow the RAN4 LS. |
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### Clarification regarding CodebookVariantsList-r16

[R2-2110627](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110627.zip) Clarification regarding CodebookVariantsList-r16 Nokia, Nokia Shanghai Bell CR Rel-16 38.331 16.6.0 2841 - F NR\_newRAT-Core, TEI16

[R2-2110628](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110628.zip) Clarification regarding CodebookVariantsList-r16 Nokia, Nokia Shanghai Bell CR Rel-16 38.306 16.6.0 0653 - F NR\_newRAT-Core, TEI16

[R2-2110629](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110629.zip) Clarification regarding CodebookVariantsList-r16 Nokia, Nokia Shanghai Bell discussion Rel-16 NR\_newRAT-Core, TEI16

Proposal 1: Define an IE SupportedCSI-RS-Resource-r16 with exactly the same fields as *SupportedCSI-RS-Resource* but parameter names *maxNumberResourcesPerBand* and *totalNumberTxPortsPerBand* changed to *maxNumberResources* and *totalNumberTxPorts* respectively.

Proposal 2: RAN2 to discuss the backward compatible change in CRs in R2-2110627/R2-2110628 for resolving the misunderstanding in resolving the issue in description of the *supportedCSI-RS-ResourceListAlt-r16* capability.

**Q3 Do companies agree with the proposals and intention of the CRs above?**

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| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| Ericsson | Yes |  |
| Qualcomm Incorporated | Yes | Nice way to clarify without causing ASN.1 backward compatibility issues. |
| OPPO | No | We intend to agree the current formula is misleading but the proposal from Nokia is kind of overkilling. One alternative is that we simply remove “PerBand” from the reused IE structure:  SupportedCSI-RS-Resource ::= SEQUENCE {  maxNumberTxPortsPerResource ENUMERATED {p2, p4, p8, p12, p16, p24, p32},  maxNumberResources INTEGER (1..64),  totalNumberTxPorts INTEGER (2..256)  }  And also modify the place referring to this structure. Then we will not struggle whether it is referred by an IE per band or an IE per band combination |
| Huawei, HiSilicon | No | In field description, it clearly describes “Indicates the list of supported CSI-RS resources across all bands in a band combination by referring to *codebookVariantsList*”, so there is no big issue for understanding.  Besides, if this ASN.1 change is supported, except for *supportedCSI-RS-ResourceListAlt-r16*, *codebookComboParametersAdditionPerBC-r16* and *codebookParametersAdditionPerBC-r16* also refer to the *SupportedCSI-RS-Resource*, need to be corrected as well? |
| Nokia | Yes | Proponent: It would be good to clarify this. We are fine with suggestion from Huawei and can update the CR as requested. |
| MediaTek | Prefer No | The current CR is backward compatible and is acceptable. However, we tend to think this kind of renaming activity is not a must. The capability meaning is clearly define in field description and the naming is not perfect and does not have any technical problem. |
| ZTE(Wenting) | Prefer No | We share the similar view as MTK. If the minorities think some modifications are needed, we also want to confirm whether can simply remove “PerBand” from the legacy IE name as OPPO suggested. |
| vivo | No | There is indeed the misunderstanding issue, but technically the original field description has pointed out the meaning without ambiguity and works fine. Such revision seems to be a little redundant and we are not sure whether future reader can really be clear about the intention of revision or somewhat further confused why there are two IEs appear to be so similar to each other. |
| Samsung | No | We see no strong need. It’s just to avoid any misunderstanding, i.e. it’s not essential. |
| Apple | We can limit outselves from big changes and go with Huawei’s suggestion…? |  |
| Intel | No, but can follow the majority | Our understanding is that nothing is actually broken and the confusion is just because of the reusing of the Rel-15 IE *SupportedCSI-RS-Resource* which has ‘PerBand’ suffix in one of the components that may cause confusion when it is used for per band and per BC capability.    If an update is needed, there is also a need to update the field description in TS38.306 for the following 2 Rel-16 capabilities which also reference the Rel-15*SupportedCSI-RS-Resource*as it uses *CodebookVariantsLIst-r16*as well. |
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### Miscellaneous corrections for Rel-16 UE capabilities

[R2-2110973](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_116-e\Docs\R2-2110973.zip) Miscellaneous corrections for Rel-16 UE capabilities Huawei, HiSilicon CR Rel-16 38.306 16.6.0 0659 - F NR\_RF\_FR2\_req\_enh, NR\_eMIMO-Core

1) Remove the prerequisite requirement on *beamCorrespondenceWithoutUL-BeamSweeping* capability for *beamCorrespondenceSSB-based-r16* capability and *beamCorrespondenceCSI-RS-based-r16* capability.

2) Add the missing description of *overlapPDSCHsFullyFreqTime-r16*.

2) Remove the description of absence of *maxTBS-Size-r16*.

**Q4 Do companies agree with the intention of the CRs above?**

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| **Company** | **Yes or No** | **Comments** |
| Ericsson | Yes for 2) and 3) | For 1), it seems what is highlighted on the CR coversheet implies that the capability should be dependent on beamCorrespondenceWithoutUL-BeamSweeping? If yes, then the change would not be needed. |
| Qualcomm Incorporated | Yes |  |
| OPPO | Yes for 1), 2),3) |  |
| Huawei, HiSilicon | Yes (proponent) | To further clarify 1), in feature list:  Supported by UEs with capability *beamCorrespondenceWithoutUL-BeamSweeping = {0,1}*  UE can indicate support for beam correspondence based on SSB/CSI-RS in case that *beamCorrespondenceWithoutUL-BeamSweeping* is supported (value 1) or not supported (value 0). However, in existing field description, it mandates UE to support *beamCorrespondenceWithoutUL-BeamSweeping*, which is not aligned with RAN4 conclusion (the approved WF RP-182879/R4-2011678). |
| Nokia | Wait for RAN4 | As we understand this is still being discussed in RAN4. We would prefer avoiding multiple iterations in the same topic so preferably this could be done once RAN4 replies with the LS?  [Huawei (proponent)]: as far as we know, RAN4 does not discuss related issue now, the approved WF is nearly one year ago but was not correctly captured in RAN2 spec. Could you indicate under which RAN4 topic this is being discussed? |
| MediaTek | Yes |  |
| ZTE(Wenting) | Yes |  |
| vivo | Yes |  |
| Samsung | Yes |  |
| Apple | Yes for all |  |
| Intel | Yes with comments | On 1) above, instead of removing the sentence, should it say the support is for UE that support with and without beam sweeping as in the feature list? |
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# Conclusions

# References

1. R2-2111058 Clarification on UL MIMO layer reporting for 1Tx-2Tx switching Huawei, HiSilicon, China Telecom, Apple CR Rel-16 38.306 16.6.0 0661 - F NR\_RF\_FR1-Core\
2. R2-2110777 Support of UL Tx switching and relation with further enhancements Ericsson discussion
3. R2-2110483 Adding UE capability of UL MIMO coherence for UL Tx switching Huawei, HiSilicon, China Telecom, Apple CR Rel-16 38.306 16.6.0 0635 - F NR\_RF\_FR1-Core R2-2108618
4. R2-2110484 Adding UE capability of UL MIMO coherence for UL Tx switching Huawei, HiSilicon, China Telecom, Apple CR Rel-16 38.331 16.6.0 2786 - F NR\_RF\_FR1-Core R2-2108619
5. R2-2110780 UL MIMO coherence for Tx switching between two carriers Ericsson discussion
6. R2-2110627 Clarification regarding CodebookVariantsList-r16 Nokia, Nokia Shanghai Bell CR Rel-16 38.331 16.6.0 2841 - F NR\_newRAT-Core, TEI16
7. R2-2110628 Clarification regarding CodebookVariantsList-r16 Nokia, Nokia Shanghai Bell CR Rel-16 38.306 16.6.0 0653 - F NR\_newRAT-Core, TEI16
8. R2-2110629 Clarification regarding CodebookVariantsList-r16 Nokia, Nokia Shanghai Bell discussion Rel-16 NR\_newRAT-Core, TEI16
9. R2-2110973 Miscellaneous corrections for Rel-16 UE capabilities Huawei, HiSilicon CR Rel-16 38.306 16.6.0 0659 - F NR\_RF\_FR2\_req\_enh, NR\_eMIMO-Core